# Properties of the light flavour octet baryons in a hypercentral model

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## Introduction

The magnetic moments of the octet baryons were found to obey approximate SU(3) symmetry a long time ago by [1]. In the last two decades, there has been great advancement of baryon magnetic moments of the octet ($J^P = \frac{1}{2}^+$) baryons, except for the $\Sigma^0$ which has a life time too short. Theoretically, there exist serious discrepancies between the quark model predictions and experimental results [2]. Various attempts involving symmetry breaking, configuration mixing, chiral quark model, meson cloud corrections, the effective mass scheme, the bag model have been made to remove the discrepancies, but with partial success. Recently, magnetic moments of heavy flavour baryons in a hyper central model have been studied [3] using effective quark mass. In this paper, we extend their scheme to the light flavour octet baryons with the tensor corrections adopted by [4].

## Methodology

The Hamiltonian of baryonic systems in hypercentral model can be written as

$$H = \frac{P_\rho^2}{2\,m_\rho} + \frac{P_\lambda^2}{2\,m_\lambda} + V(\rho,\lambda) = \frac{P_x^2}{2\,m} + V(x) \quad (1)$$

For the present study, we consider the hyper central potential $V(x)$ as [3]

$$V(x) = -\frac{\tau}{x} + \beta x^\nu + \kappa + V_{spin}(x) \qquad (2)$$

Here, $\tau$ of hyper Coulomb, $\beta$ of confining term and $\kappa$ are the model parameters. The spin dependent part of the three body interaction is taken as

$$V_{spin}(x) = -\frac{1}{4}\alpha_s \frac{e^{\frac{-x}{x_0}}}{x x_0^2} \sum_{i<j} \frac{\vec{\sigma_i}\cdot\vec{\sigma_j}}{6 m_i m_j} \vec{\lambda_i}\cdot\vec{\lambda_j} \quad (3)$$

The baryon masses are then obtained as

$$M_B = \sum_i m_i + \langle H \rangle + \kappa_{cm} \qquad (4)$$

Here, $\kappa_{cm}$ is the center of mass correction term.

The magnetic moment of baryons are obtained in terms of the magnetic moments of the constituent quarks as

$$\mu_B = \sum_i \langle \phi_{sf} \mid \mu_i \sigma_i \mid \phi_{sf} \rangle \qquad (5)$$

Here $\mu_i = \frac{e_i}{2 m_i^{eff}}$, $e_i$ and $\sigma_i$ represents the charge and the spin of the quark($\mathbf{s}_i = \frac{\sigma_i}{2}$) constituting the baryon state, $|\phi_{sf}\rangle$ represents the spin-flavour wave function of the respective baryon state [5] and the effective quark mass is defined as [3]

$$m_i^{eff} = m_i \left( 1 + \frac{\langle H \rangle + \kappa_{cm}}{\sum_i m_i} \right) \qquad (6)$$

For the present calculation, we have employed the same mass parameters of the light flavour quarks(u,d,s) as used in [3]. The total expressions for the baryon magnetic moment with tensor correction as given by [4]. We incorporate the tensor correction and is expressed as $\mu_{B_T} = \mu_B + T_\delta(B)\delta$, where $T_\delta(B)$ and $\delta$ are the same as given by [4].

## Results and Discussion

The computed results with different choices of the potential index $\nu$ for masses and magnetic moments of light flavour octet baryons are listed in Table I. The calculated magnetic moments are found to be in good agreement with experimental data at $\nu$=0.7 in hyper central model.

TABLE I: Light flavour octet baryon masses and magnetic moments

| Baryon | Model | Mass in MeV | | Magnetic moments in $\mu_N$ | | |
|---|---|---|---|---|---|---|
| | | Our | Others | Our | | Others |
| | | | | Without Tensor | With Tensor | |
| | 0.7 | 967.41 | 938.27[6] | 2.93 | 2.93 | 2.79[7] |
| uud(p) | 1.0 | 931.08 | 938.27[7] | 3.04 | 3.04 | 2.79[8] |
| | 1.5 | 924.27 | | 3.07 | 3.07 | 2.88[2] |
| | | | | | | 2.79[4] |
| | 0.7 | 971.74 | 939.57[6] | -1.93 | -1.93 | -1.91[7] |
| ddu(n) | 1.0 | 935.77 | 939.56[7] | -2.07 | -2.07 | -2.07[8] |
| | 1.5 | 929.04 | | -2.04 | -2.04 | -1.91[2] |
| | | | | | | -1.91[4] |
| | 0.7 | 1127.34 | 1115.68[6] | -0.65 | -0.65 | -0.61[7] |
| uds($\Lambda$) | 1.0 | 1090.29 | 1115.68[7] | -0.68 | -0.68 | -0.71[8] |
| | 1.5 | 1084.16 | | -0.69 | -0.68 | -0.71[2] |
| | | | | | | -0.61[4] |
| | 0.7 | 1235.98 | 1189.39[6] | 2.54 | 2.53 | 2.46[7] |
| uus($\Sigma^+$) | 1.0 | 1198.84 | 1189.37[7] | 2.63 | 2.61 | 2.47[8] |
| | 1.5 | 1191.50 | | 2.64 | 2.62 | 2.59[2] |
| | | | | | | 2.39[4] |
| | 0.7 | 1184.06 | 1192.64[6] | 0.85 | 0.77 | 0.83[2] |
| uds($\Sigma^0$) | 1.0 | 1147.27 | 1192.64[7] | 0.87 | 0.80 | 0.63[4] |
| | 1.5 | 1139.97 | | 0.88 | 0.81 | - |
| | 0.7 | 1243.71 | 1197.45[6] | -0.95 | -1.08 | -1.16[7] |
| dds($\Sigma^-$) | 1.0 | 1205.99 | 1197.45[7] | -0.98 | -1.11 | -1.01[8] |
| | 1.5 | 1199.06 | | -0.98 | -1.12 | -0.92[2] |
| | | | | | | -1.12[4] |
| | 0.7 | 1331.65 | 1314.64[6] | -1.46 | -1.39 | -1.25[7] |
| ssu($\Xi^0$) | 1.0 | 1297.09 | 1314.86[7] | -1.49 | -1.43 | -1.52[8] |
| | 1.5 | 1291.43 | | -1.50 | -1.43 | -1.45[2] |
| | | | | | | -1.24[4] |
| | 0.7 | 1340.44 | 1321.39[6] | -0.54 | -0.59 | -0.65[7] |
| ssd($\Xi^-$) | 1.0 | 1306.55 | 1321.71[7] | -0.55 | -0.60 | -0.61[8] |
| | 1.5 | 1299.61 | | -0.55 | -0.60 | -0.62[2] |
| | | | | | | -0.69[4] |

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## References

[1] S.Colemn *et al.*, Phys. Rev. Lett.,**6**, 423 (1961)

[2] M.Bagchi *et al.*, Europhys. Lett.,**75**, 548 (2006)

[3] Patel B *et al.*, J. Phys. G, **35**, 065001 (2008); Patel B *et al.*, Pramana - J. Phys. **72**, 679 (2009); Majethiya A *et al.*,Eur. Phys. J **A 38**, 307 (2008).

[4] S.K.Gupta *et al.*, Phys. Rev. **D 36**, 307 (1987)

[5] Yu.A.Simonov *et al.* Phys. Rev. **D 65**, 094013 (2002)

[6] Phuoc Ha , J.Phys. G,**35**, 075006 (2008)

[7] Amsler C *et al.* (Particle Data Group), Phys. Lett. **B 667**, 1 (2008).

[8] Bae M. *et al.* , J.Phys. G,**22**, 199 (1996)